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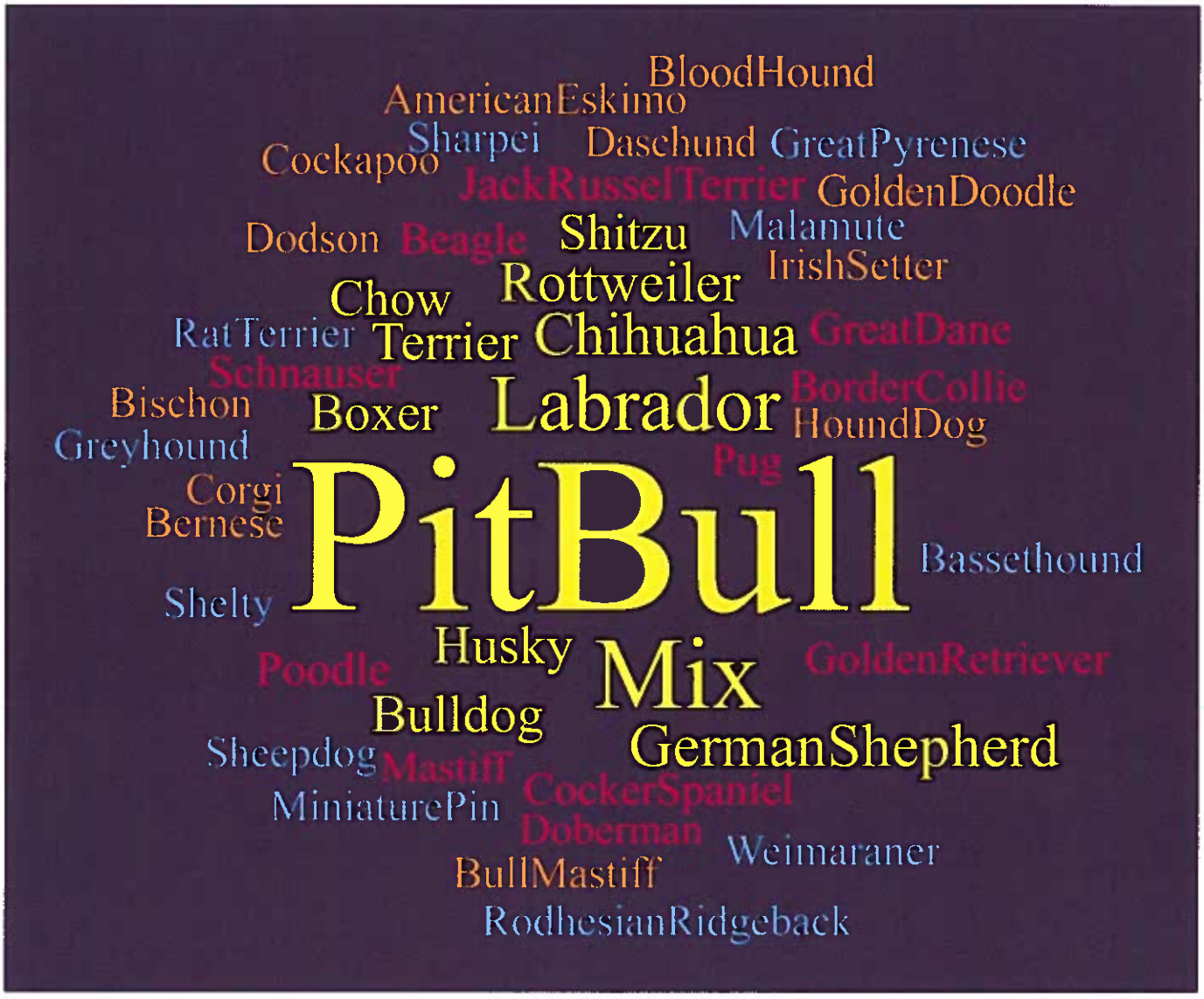

Word cloud of the frequency of breeds identified in serious dog bite injuries in a 4-year review of 1616 consecutive dog bite injuries treated at Children's Healthcare of Atlanta (CHOA), a level I trauma center.

Opposition to Senate Bill 239

House Local Government Committee

Michigan House of Representatives

September 7, 2016

Written Testimony by DogsBite.org

Source of graphic:
Characteristics of 1616 Consecutive Dog Bite Injuries at a Single Institution, by Michael S. Golinko, MD, MA, Brian Arslanian, MD2, and Joseph K. Williams, MD, FAAP, *Clinical Pediatrics*, August 2016

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DogsBite.org is 501(c)(3) nonprofit dog bite victims' organization dedicated to reducing serious dog attacks.

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Table of Contents

Attachments

1. Characteristics of 1616 Consecutive Dog Bite Injuries at a Single Institution, by Michael S. Golinko, MD, MA, Brian Arslanian, MD2, and Joseph K. Williams, MD, FAAP, *Clinical Pediatrics*, August 2016
2. Dog bites of the head and neck: an evaluation of a common pediatric trauma and associated treatment, by Daniel C. O'Brien, BS, Tyler B. Andre, MD, Aaron D. Robinson, MD, Lane D. Squires, MD and Travis T. Tollefson, MD, MPH, *American Journal of Otolaryngology*, Published Online: September 25, 2014.
3. Mortality, Mauling, and Maiming by Vicious Dogs, by John K. Bini, MD, Stephen M. Cohn, MD, Shirley M. Acosta, RN, Marilyn J. McFarland, RN, MS, Mark T. Muir, MD and Joel E. Michalek, PhD; for the TRISAT Clinical Trials Group, *Annals of Surgery*, April 2011 - Volume 253 - Issue 4 - p 791–797

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DogsBite.org is a national dog bite victims' group dedicated to reducing serious dog attacks. Through our work, we hope to protect both people and pets from future attacks. Our website contains a wide collection of data to help policy-makers and citizens learn about dangerous dogs. Our research focuses on pit bull type dogs. Due to selective breeding practices that emphasize aggression and tenacity, this class of dogs negatively impacts communities the most.

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Summary of Key Peer-Reviewed Medical Studies (2011-2016)

There are over a dozen peer-reviewed medicals studies published in a number of medical science publications -- including, *Clinical Pediatrics, American Journal of Otolaryngology,* and *Annals of Surgery* -- that show similar results in retrospective reviews of level I trauma and emergency room centers for dog bites. Their findings show a higher frequency of pit bull injuries, a higher degree of severity of injuries and higher hospital charges than attacks by other breeds of dogs. This is a growing body of studies, over 20-years. Doctors continue to find these same shared results.

For brevity we are including three recent key studies. The first, Characteristics of 1616 Consecutive Dog Bite Injuries at a Single Institution (2016), is a 4-year review of Children's Healthcare of Atlanta (CHOA), the only pediatric level I trauma center in Georgia. The study refers back to eight different medical studies (starting in 2000). Their findings are consistent with six of them regarding pit bull injuries compared to other dog breeds: higher frequency, higher severity and higher costs.

> *Our data confirm what detractors of the breed and child advocates suggest—that, with rare exceptions, children and pit bulls do not mix well. Of the 8 studies listed in Table 5, 6 report pit bulls as the most prevalent breed, and in many cases, they inflicted the most severe injuries. A large study at Children's Hospital of Pennsylvania showed that over a 12-year period, 25% of injuries were caused by a pit bull, and two-thirds of those required an operation. Our data were consistent with others, in that an operative intervention was more than 3 times as likely to be associated with a pit bull injury than with any other breed. Half of the operations performed on children in this study as well as the only mortality resulted from a pit bull injury. Our data revealed that pit bull breeds were more than 2.5 times as likely as other breeds to bite in multiple anatomical locations. Although other breeds may bite with the same or higher frequency, the injury that a pit bull inflicts per bite is often more severe. Consistent with these findings is that of Bini et al, who reported on 228 patients and found that attacks by pit bulls resulted in a higher injury severity score, lower Glasgow coma score, higher risk of death, and higher hospital charges than attacks by any other breed.*

The second study, Dog Bites of the Head and Neck: An Evaluation of a Common Pediatric Trauma and Associated Treatment (2014), is a review of 334 dog bite cases from the University of California Davis Medical Center, a level I trauma center in Sacramento. The study shows a higher frequency of pit bull injuries, a higher degree of severity of these injuries and a greater number of surgical interventions required --

5 times the relative rate. The authors also state, "The key finding from our second objective, determining the dogs responsible for bites, is the importance of pit bull terriers in patients with dog bites of the head and neck. The findings of this study are consistent with and extend from previous publications [5,7,11–13,16,21,22,29]."

> ***Results:*** *334 unique dog bites were identified, of which 101 involved the head and neck. The mean patient age was 15.1 ± 18.1 years. Of the more than 8 different breeds identified, one-third were caused by pit bull terriers and resulted in the highest rate of consultation (94%) and had 5 times the relative rate of surgical intervention. Unlike all other breeds, pit bull terriers were relatively more likely to attack an unknown individual (+31%), and without provocation (+48%). Injuries of the head and neck had an average follow-up of 1.26 ± 2.4 visits, and average specialty follow-up of 3.1 ± 3.5 visits.*
>
> ***Conclusions:*** *The patients most likely to suffer dog bite injuries of the head and neck are children. Although a number of dog breeds were identified, the largest group were pit bull terriers, whose resultant injuries were more severe and resulted from unprovoked, unknown dogs. More severe injuries required a greater number of interventions, a greater number of inpatient physicians, and more outpatient follow-up encounters.*

The final study, Mortality, Mauling, and Maiming by Vicious Dogs (2011), is a retrospective review of all dog bite cases admitted into the level I trauma center at University Hospital San Antonio from 1994 to 2009 and treated by the Trauma and Emergency Surgery Service. The examination of these cases showed that compared to attacks by other breeds of dogs, attacks by pit bulls had a higher degree of severity of injury, higher median hospital charges and a higher risk of death.

> ***Results:*** *Our Trauma and Emergency Surgery Services treated 228 patients with dog bite injuries; for 82 of those patients, the breed of dog involved was recorded (29 were injured by pit bulls). Compared with attacks by other breeds of dogs, attacks by pit bulls were associated with a higher median Injury Severity Scale score (4 vs. 1; P = 0.002), a higher risk of an admission Glasgow Coma Scale score of 8 or lower (17.2% vs. 0%; P = 0.006), higher median hospital charges ($10,500 vs. $7200; P = 0.003), and a higher risk of death (10.3% vs. 0%; P = 0.041).*
>
> ***Conclusions:*** *Attacks by pit bulls are associated with higher morbidity rates, higher hospital charges, and a higher risk of death than are attacks by other breeds of dogs. Strict regulation of pit bulls may substantially reduce the US mortality rates related to dog bites.*

Characteristics of 1616 Consecutive Dog Bite Injuries at a Single Institution

Clinical Pediatrics
1–10

DOI: 10.1177/0009922816657153
cpj.sagepub.com
SAGE

Michael S. Golinko, MD, MA[1], Brian Arslanian, MD[2], and Joseph K. Williams, MD, FAAP[2,3]

Abstract

Dog bite injuries remain a common form of pediatric trauma. This single-institution study of 1616 consecutive dog bite injuries over 4 years revealed a much higher prevalence of dog bites as compared with other similar centers. Though inpatient admission was rare (9.8%), 58% of all patients required laceration repair, primarily in the emergency department. Infants were more than 4 times as likely to be bitten by the family dog and more than 6 times as likely to be bitten in the head/neck region. Children ≤5 years old were 62% more likely to require repair; and 5.5% of all patients required an operation. Pit bull bites were implicated in half of all surgeries performed and over 2.5 times as likely to bite in multiple anatomic locations as compared to other breeds. The relatively high regional prevalence and younger age of injured patients as compared with other centers is a topic of further study but should draw attention to interventions that can minimize child risk.

Keywords

dog bite injury, pediatric trauma, repair of dog bites

Introduction

Dog bite repairs were among the top 5 reconstructive procedures performed by plastic surgeons, and this number, nearly 27 000 annual repairs, exceeded head/neck and lower-extremity reconstruction.[1] The management of dog bite injuries range from simple washouts and laceration repair to more complex procedures such as craniotomies or replantation. Interestingly, the first partial face transplant was performed on a woman who had been attacked by her Labrador.[2,3]

From reviewing the statistics in Table 1, it is likely that plastic surgeons interact with only a small fraction of patients who have been injured by a dog and often the most severe. It is emergency department (ED) physicians, pediatricians, primary care providers, and parents, however, who are the vital frontline in education, treatment, and prevention regarding dog bite injuries.

Although precautions can be taken to prevent injury, the trends in the personal and financial cost of dog bite injuries have only increased in recent years. There was an 86% increase in hospitalizations from 1993 to 2008[10] and an 82% increase in fatal dog attacks from the 1980s to 2012.[11] Paid homeowners' insurance claims too have increased from $324 to $478 million in just 8 years.[12]

This study stemmed from the high prevalence of dog bite injuries treated at our pediatric tertiary hospital, with an aim to quantify the scope of the problem and identify potential targets of intervention for primary care providers. For surgeons managing extremity and facial trauma, the ultimate goal is to reduce the amount of severe injury encountered by drawing both clinician and lay attention to what may be a preventable threat to children's safety.

Methods

After institutional review board approval, a 4-year retrospective chart review was conducted from ED charts at the Children's Healthcare of Atlanta (CHOA), the only pediatric level I trauma center in the state. Inclusion criteria were the following: patients <20 years old, male or female, initial triage in the CHOA ED for a dog bite or transfer from another center where primary treatment had not been

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Table 1. Recent Statistics on Dog Bite Injuries.

- 83.3 Million dogs living in more than 50 million households[4]
- 4.5 Million annual dog bites; ~885 000 require medical attention; ~400 000 treated in the ED[5]
- 64.9% Of bites are to the head and neck[6]
- Most prevalent age group: 5-9 years old[6]
- Up to 50% of children may develop posttraumatic stress disorder[7]
- 55.6% Of all mortalities occur in children <10 years old[8]
- 78% Of all deaths from dog attacks between 2005 and 2013 were from pit bulls and Rottweilers[9]

administered, and at least 1 full-thickness wound. Exclusion criteria were as follows: young adults >20 years old, triage visits for suture removal from a dog bite, treatment of a dog bite where initial treatment took place at another center, and bites from animals other than dogs.

Statistical Methods

All data were stored in Microsoft Excel (Microsoft Corporation, Redmond, WA) and aggregate statistics, such as means and SDs, were calculated using Excel. Contingency tables were created for categorical variables (eg, attack by pit bull vs non–pit bull); odds ratios (OR) and CIs were calculated using http://statpages.org/ctab2x2.html. Statistical significance ($P < .05$) was reported with a standard 2-tailed P value, using Fisher's exact test. Standard t tests were used in statistical comparison of means and proportions.

Results

Triage Characteristics

A total of 1616 consecutive patients were included. Patients were bitten in 118 unique cities; however, in 320 (19.8%) cases, the city of bite could not be determined. Also, 10 patients (0.6%) were from out of state, and 192 patients (11.8%) were referred from, but not treated at, an outside facility.

As Table 2 summarizes, the majority of patients were young males of school age, and half of all patients were between 5 and 12 years of age. Approximately the same percentage of family dogs and dogs familiar to the child were implicated in injuries. Head and neck injuries (56.5%) were the most prevalent. It was found that 1477 (91.3%) children were bitten in 1 anatomical area, 98 (6.1%) in 2 areas, 31 (1.9%) in 3 areas, and 3 (0.1%) in 4 areas. Canine breed was identified by patient or family report in 31.3% of medical charts.

Of the 46 breeds identified, the 3 most prevalent were 38.5% pit bull (also identified as Staffordshire bull terrier, American Staffordshire terrier, or bull terrier), 13.0% mixed breeds, and 8.1% Labradors. Of the mixed breeds (n = 66), 11 were pit bull mixes, 12 Labrador mixes, and 4 Labrador/pit bull mixes. Figure 1 illustrates the relative frequency of biting breeds, with font size being a function of relative proportion.

Table 2. Patient- and Dog-Related Outcome Variables.

Patient Variables	Value (%)
Patients	1616
Percentage male	56.3%
Percentage female	43.7%
Patient age group	6.8 Years (5 days to 20 years)
0-1 Years old	144 (8.9)
1-5 Years old	428 (26.5)
5-12 Years old	808 (50.0)
>12 Years old	236 (14.6)
City of bite identified	1296 (80.2)
Bite injury variables	
Family dog	753 (46.6)
Known to the child (not family)	655 (40.5)
Unknown dog	205 (12.7)
Dog breeds identified	509 (31.3)
Anatomical area	
Head/Neck	1004 (56.5)
Upper extremity	398 (22.4)
Lower extremity	252 (14.2)
Trunk	98 (5.5)
Other	25 (1.4)

Characteristics of Injury After Triage

Although more than 90% of patients were ultimately discharged, approximately 50% of those still required laceration repair. Approximately 10% of patients required inpatient admission, and 50% of those required an operation; 4.0% (n = 65) of patients returned to the ED with a soft-tissue infection (see Figure 2).

Age-Group Analysis

Contingency tables were calculated to compute the OR of the association of a specific age group or groups (risk

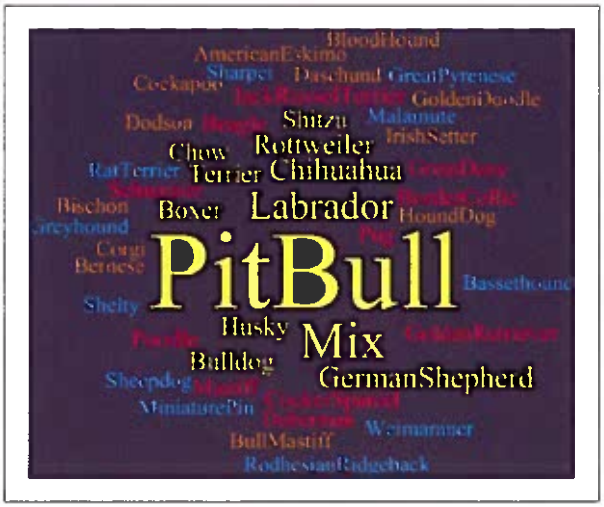

Figure 1. Word cloud of the frequency of breeds identified.

factor) with the presence or absence of an injury characteristic—that is, injury in the head/neck area. OR regarding anatomical areas assumes the likelihood of at least 1 bite in each area. Table 3 illustrates these data, with statistically significant results in bold.

Of note, children 5 years old and younger were approximately 62% more likely to require repair in any setting and were between 3 and 6 times as likely to suffer a head and neck injury as compared with other groups. Infants were more than 4 times as likely to be bitten by the family dog and more than 6 times as likely to be bitten in the head/neck region. Lower-extremity injury correlated directly with age. Teenagers were more than twice as likely to sustain extremity injuries and be injured by an unknown dog or a pit bull. Bite injury to the lower extremity was statistically less likely in children younger than 5 years and more likely in children older than 5 years. Dog bites in more than 1 anatomical location was 1.7 times as likely in children 12 years and older as compared with all younger groups. No one age group was any more likely to require operative intervention than another.

Features and Morbidity of Patients With the Most Severe Injuries

In all, 5.5% (89) of patients underwent surgery; of these, 68.5% involved the head/neck region. Of the breeds identified, 50% involved pit bulls. The mean age was 6.3 years old (range = 5 days to 17 years). Table 4 enumerates the primary procedure performed.

With regard to breed, operative intervention was most strongly associated with a pit bull injury: OR = 3.361 (CI = 2.011-5.592); $P < .001$. Pit bull breeds were also more likely to bite in multiple anatomical locations, OR = 2.660 (CI = 1.598-4.436); $P < .001$. Four returns to the ED from this group were noted, including 2 for an abscess, 1 for exposed hardware, and 1 for wound necrosis. Known operative complications included the following: hand amputation after attempted revascularization, a growing skull fracture, and wound dehiscence with return to the operating room for skin graft placement.

The lone mortality involved a 5 day-old girl attacked on the head by the family's pit bull. The child underwent emergency craniotomy. Her postoperative course was complicated by acute respiratory distress syndrome, neurogenic pulmonary edema, and transfusion-related acute lung injury. Despite maximal ventilator support, she was persistently hypoxic and succumbed on postoperative day 3.

Discussion

Current Literature on Dog Bite Injuries

Dog bite injuries are neither new nor an unstudied phenomenon in children. Table 5 summarizes some of the recent literature emerging from pediatric centers comparable to our own.

On average, the centers cited saw approximately 120 dog bite injuries per year, per institution (range between 17 and 204 per year).[18] Somewhat surprising was that our center averaged more than 400 patients per year. The relatively low population density of Georgia, allowing for larger dogs, and the scarcity of other pediatric trauma centers in the state may account for this high prevalence, but further detailed study is needed to see if dogs are truly biting at a higher rate. There are significant gaps in the literature, as Table 5 illustrates, including detailed data on the biting dog, disposition of the child after ED triage, age in relation to multiple variables, frequency and type of repair, and types of operations performed.

Age and Injury Patterns

The largest ED survey published found that boys 5 to 9 years old[21] are most susceptible to bite injury. In addition to domestic studies, the world literature is clear: in reports from Canada,[22] Spain,[23] Austria,[24] South Africa,[13] Australia,[25] Peru,[26] India,[27] Hong Kong,[28] and Bhutan,[29] persons younger than 18 years are most at risk for dog bite injury. Our study certainly was consistent with others findings; however, a breakdown into clinically significant age categories provided some new findings.

The age-group analysis in this study indicates that younger children than previously thought are more at risk for injury. Infants (≤1 year old), more so than any

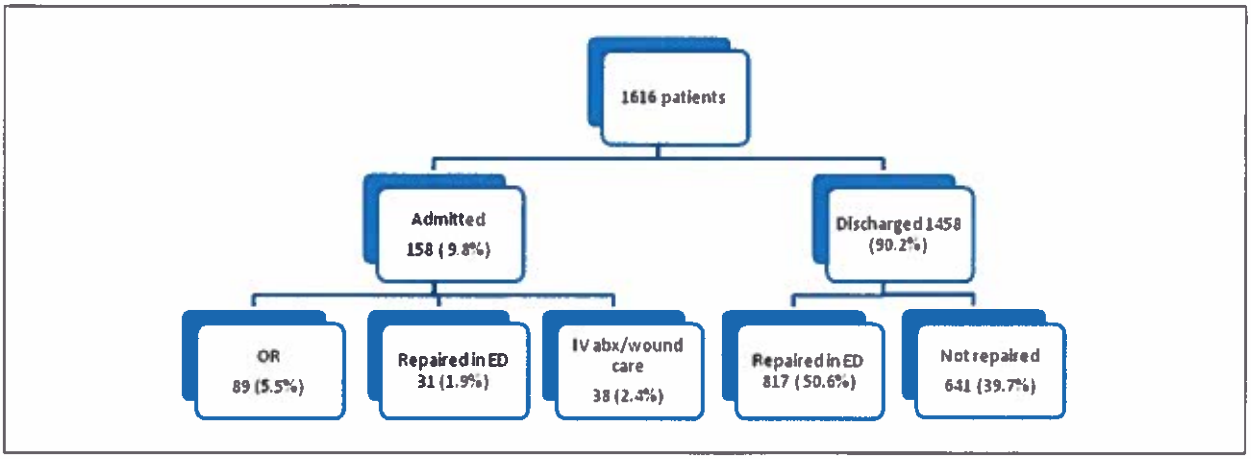

Figure 2. Patient disposition from the ED.
Abbreviations: ED, emergency department; OR, odds ratio IV, intra-venous ABX, antibiotics .

other age group in this study, were most likely to suffer a head/neck injury and be bitten by the family dog or a dog the family knows, and least likely to be bitten by an unknown dog. This was a surprising finding given that most literature points to older children being more susceptible. Moreover, the one mortality in this study of a 5-day old baby girl attacked by her family pit bull should be sobering evidence enough to exercise extreme caution in this age group when in contact with that particular breed. Children younger than 5 years were nearly half as likely to suffer an extremity injury, whereas children older than 12 years were over twice as likely to. These trends may not be merely a matter of total body surface area and height, but also age-specific behavior of children toward dogs—that is, young children kissing or nuzzling the dog and older children playing catch, feeding, washing, or petting.[30,31] Although the data seem to support a common sense assumption, knowledge of this propensity can guide parents when supervising their young children in the presence of the family pet.

The High-Risk Animal: A Dog You Know

Unfortunately, familiarity may lead to injury. The existing literature reveals that the family dog inflicts injury between 27% and 45% of the time, more so than a neighbors' dog or a stray.[14,17-19] Some studies we reviewed, however, did not distinguish between a dog known to the family, such as a neighbor's dog, and the family dog. This is a potentially important distinction because we suspect that the more parents (and children) are familiar with a dog, the less vigilant they may be. Our data were consistent with others findings that the family dog was statistically no more likely to be involved in a bite injury than a familiar dog, however: 46.6% and 40.5%, respectively($P > .05$), and again, infants were most at risk in each of these categories. Whether this finding is indicative of parents' level of supervision around the family dog or whether it is simply because children have more chances to be bitten by the family dog as compared with a dog that is not routinely around, we interpret the data to indicate that parents should demonstrate equal vigilance in all cases. Indeed, in one study of 56 modifiable risk factors, the strongest was "the absence of an able-bodied person to intervene"—present in more than 87% of injuries reviewed.[32]

Pit Bull Injuries

Our data confirm what detractors of the breed and child advocates suggest—that, with rare exceptions, children and pit bulls do not mix well. Of the 8 studies listed in Table 5, 6 report pit bulls as the most prevalent breed, and in many cases, they inflicted the most severe injuries.[17] A large study at Children's Hospital of Pennsylvania showed that over a 12-year period, 25% of injuries were caused by a pit bull, and two-thirds of those required an operation.[33] Our data were consistent with others, in that an operative intervention was more than 3 times as likely to be associated with a pit bull injury than with any other breed. Half of the operations performed on children in this study as well as the only mortality resulted from a pit bull injury. Our data revealed that pit bull breeds were more than 2.5 times as likely as other breeds to bite in multiple anatomical locations. Although other breeds may bite with the same or higher frequency, the injury that a pit bull inflicts per bite is often more severe. Consistent with these findings is that of Bini et al,[17] who reported on 228 patients and found that attacks by pit bulls resulted in a higher injury severity score, lower

Table 3. Characteristics by Age Group, as Percentage of the Total in Each Group.[a]

	Age Group							
	0 to ≤1.0 Year Old (144)		1.0 < Age ≤5.0 Years Old (533)		5.0 < Age ≤ 12.0 Years Old (746)		<12.0 Years Old (193)	
Characteristics	n (%)	OR (CI), *P* Value	n (%)	OR (CI), *P* Value	n (%)	OR (CI), *P* Value	n (%)	OR (CI), *P* Value
Head/Neck injury	109 (75.7)	**6.197 (4.122-9.350)**	389 (73.0)	**3.043 (2.429-3.816)**	420 (56.3)	0.991 (0.816-1.204)	87 (45.1)	1.194 (0.879-1.622)
Upper extremity	25 (17.4)	0.962 (0.559-1.536)	102 (19.1)	0.784 (0.605-1.017)	201 (26.9)	1.252 (0.992-1.581)	70 (36.3)	**2.348 (1.688-3.263)**
Lower extremity	9 (6.3)	**0.452 (0.212-0.930)**	50 (9.4)	**0.529 (0.376-0.743)**	145 (19.4)	**1.635 (1.234-2.166)**	48 (24.9)	**2.231 (1.535-3.238)**
Trunk	8 (5.6)	1.118 (0.489-2.458)	24 (4.5)	0.675 (0.409-1.106)	53 (717)	1.389 (0.904-2.134)	13 (6.7)	1.198 (0.624-2.260)
Other	1 (0.7)	0.468 (0.023-3.288)	5 (0.9)	0.510 (0.167-1.448)	14 (1.8)	1.488 (0.632-3.531)	5 (2.6)	**5.657 (2.7-11.789)**
≥2 Anatomical areas	10 (6.9)	0.846 (0.408-1.703), *P* = .749	32 (6.0)	**0.627 (0.408-0.961)**	73 (9.8)	1.310 (0.911-1.883)	24 (12.4)	**1.728 (1.052-2.819)**
Operative repair	9 (6.3)	1.219 (0.558-2.576)	25 (5.8)	1.364 (0.860-2.160)	48 (5.9)	0.960 (0.611-1.506)	7 (3.0)	0.449 (0.158-1.167)
Family dog	97 (67.4)	**4.326 (2.973-6.305)**	264 (49.5)	**1.644 (1.334-2.025)**	306 (41.0)	0.877 (0.721-1.068), *P* = .188	86 (44.6)	**1.611 (1.182-2.195)**
Known dog	38 (26.4)	**1.617 (1.074-2.427)**	206 (26.4)	1.228 (0.992-1.520)	338 (45.3)	**1.386 (1.129-1.702)**	74 (38.3)	1.441 (1.049-1.979)
Unknown dog	9 (6.3)	0.498 (0.233-1.026)	62 (11.6)	0.940 (0.676-1.306)	101 (13.5)	1.158 (0.855-1.569)	33 (13.5)	**1.667 (1.086-2.548)**
Pit bull injury	15 (10.4)	0.952 (0.523-1.706)	48 (9.0)	0.706 (0.493-1.009)	99 (13.2)	1.255 (0.919-1.715)	31 (16.1)	**1.644 (1.059-2.541)**

[a]Odds ratios (ORs) are reported, calculated with age as the independent variable. Confidence intervals are reported; those that are statistically significant, with $P < .05$, are in bold.

Table 4. Frequency of Operative Procedures in 89 Patients Suffering Dog Bite Injuries.

Operating Room Procedure	n (%)
Irrigation and closure	60 (65.9)
Canalicular repair	11 (12.1)
Wound irrigation and debridement	4 (4.4)
Craniotomy	3 (3.3)
Dural repair	2 (2.2)
Facial nerve repair	1 (1.1)
Local facial flap	1 (1.1)
ORIF humerus	1 (1.1)
ORIF mandible	1 (1.1)
ORIF radius	1 (1.1)
ORIF phalanx	1 (1.1)
Replant lip	1 (1.1)
Revascularization of hands	1 (1.1)
Tooth extraction	1 (1.1)

Abbreviation: ORIF, open reduction, internal fixation.

Glasgow coma score, higher risk of death, and higher hospital charges than attacks by any other breed.[17]

Morbidity of Dog Bite Injuries

Whereas existing studies focus on only bites repaired in the ED or only the most severe requiring the OR, this study sought to follow patients longitudinally throughout their course from triage to treatment and disposition. Summarizing from Table 5, national admission rates range between 6.4%[15] and 22.5%,[16] and operative rates range between 3.1%[15] and 25.2%.[20] This study revealed that 57.9% of patients required some form of repair following a dog bite, 9.8% of patients required inpatient admission, and more than 50% of admissions were associated with an operation. Younger children (mean age = 6.3 years) tended to require an operation. Although the majority of injuries required only washout and closure, revascularization of the hands, ORIF of long bones, and craniotomies were among the singular reminders of the severity of trauma a dog can inflict on a child; also, whereas the common laceration may not be preventable in many cases, these severe injuries often need not occur. Regardless of treatment setting, copious irrigation with betadine and saline, sharp debridement of any macerated or damaged tissues, deep closure with monocryl as needed, and loose skin approximation with permanent sutures, along with a 10-day course of amoxicillin/clavulanate potassium or clindamycin is advised. Families should be counseled that avoidance of secondary infection is more important in the short term than cosmesis because an unsightly scar can always be revised.

Limitations and Bias

Because this was a retrospective review of triage and medical record data, certain variables such as breed of dog could not be independently verified. There may be a reporting bias for typically "biting" breeds, such as pit bulls. Although 1616 consecutive children were included, 1608 of these were unique because 8 children were bitten at 2 separate time points and returned to the ED for treatment. Analysis of the same or different dog responsible for each bite was beyond the scope of this study but would be important to investigate. Another source of error is in the city of bite because data recorded where the bite took place may not necessarily be where the animal normally resides. Often, bites occurred at home, for which data would be accurate. Comparison of admission, ED, and surgical repair rates are biased by institutional resources and local physician practice patterns. The authors acknowledge that etiology of a dog bite is complex and multifactorial, depending not only on the canine's characteristics, but also on owner training, child behavior, and the specific conditions when the bite occurred. Operative complications and returns to the ED following a repair for a soft-tissue infection are likely underestimated as well because many patients may have sought care at their local physician's office and not returned to the original point-of-service.

Potential Public Health Interventions

The health care providers who see the accidental and often deleterious effects of dog bite injury are vastly outnumbered by the heads of the approximately 56.7 million households[34] who own dogs under the likely assumption that the dog will not harm them or their child. Several studies reflect this hypothesis[35,36] and revealed that the majority of parents assumed that their infants were not at risk for an attack. As a Cochrane database review suggests, it is often better to educate the parents and pediatricians rather than children directly.[37] Alarmingly, one survey of 254 parents revealed that only two-thirds believed that a dog could be the cause of a fatal infant injury.[36]

At least in the United States, "man's best friend" is part of the national psyche and is reinforced for children in the form of stuffed animals, cartoon characters, and animated movies. In this milieu, it is all the more important for any clinician, using data from this study and others, to caution parents appropriately about the potential hazards that specific canine situations may pose to their child. Inquiring and counseling about dogs at home and in the neighborhood should be as important and integral a part of any pediatric encounter, as would be cautioning

Table 5. Selected Studies of Dog Bite Injuries With Select Variables That Could Be Targets of Public Health Intervention.

Authors (Year Published)	Study Length(years)	Patients (n)	City (Type of Site)	Two Most Prevalent Breeds Documented (%)	Percentage Family Dog	Percentage Familiar (But Not Family)	Percentage Unknown	Percentage Admitted/ Operating Room	Mean or Most Prevalent Age Range (years)
Dwyer et al,[13] 2007	13	1871	Cape, Town South Africa (1 Children's Hospital)	• PB 28% • GS 21% • 1%					6.8 years old
Daniels et al,[14] 2009	7	1347	Indianapolis, IN (2 children's hospitals)	• PB 12% • GS 2.4% • 28% (inpatient only)	37%	33%	7%	8.1%/4.5%	7.8 Years old
Kaye et al,[15] 2009	5	551	Philadelphia, PA (children's hospital)	• PB 50.9% • R 8.9% • 48.8%	68.8% (Family + dog friend)			6.4%/3.1%	6-12 Years old (51%)
Chen et al,[16] 2013	5	537	Aurora, CO (children's hospital)	• M 23% • L 13.7%	89.8% (Family + dog friend)		11.2%	22.5% Admit	68% ≤ 5 Years old
Bini et al,[17] 2011	15.5	228 (Admitted only)	San Antonio, TX (trauma hospital)	PB 35%	44.8%	43.1%	12.1%		21 Years old
Bernardo et al,[18] 2000	1	204	Pittsburgh, PA (children's hospital)	• PB 19% • GS 12% • 47%	27%	28%			6.8 Years old; <5 Years: 49%
Reisner et al,[19] 2011	3.5	203	Philadelphia, PA (children's hospital)	• M 28% • PB 22%	72% (Family + dog friend)		9%		7.2 Years old
Wu et al,[20] 2011	5	87	Springfield, MA (tertiary hospital)					25.2% OR	6.8 Years old

Abbreviations: PB, pit bull; GS, German Shepherd; R, Rottweiler Pincher/Rottweiler; M, mixed; L, Labrador.

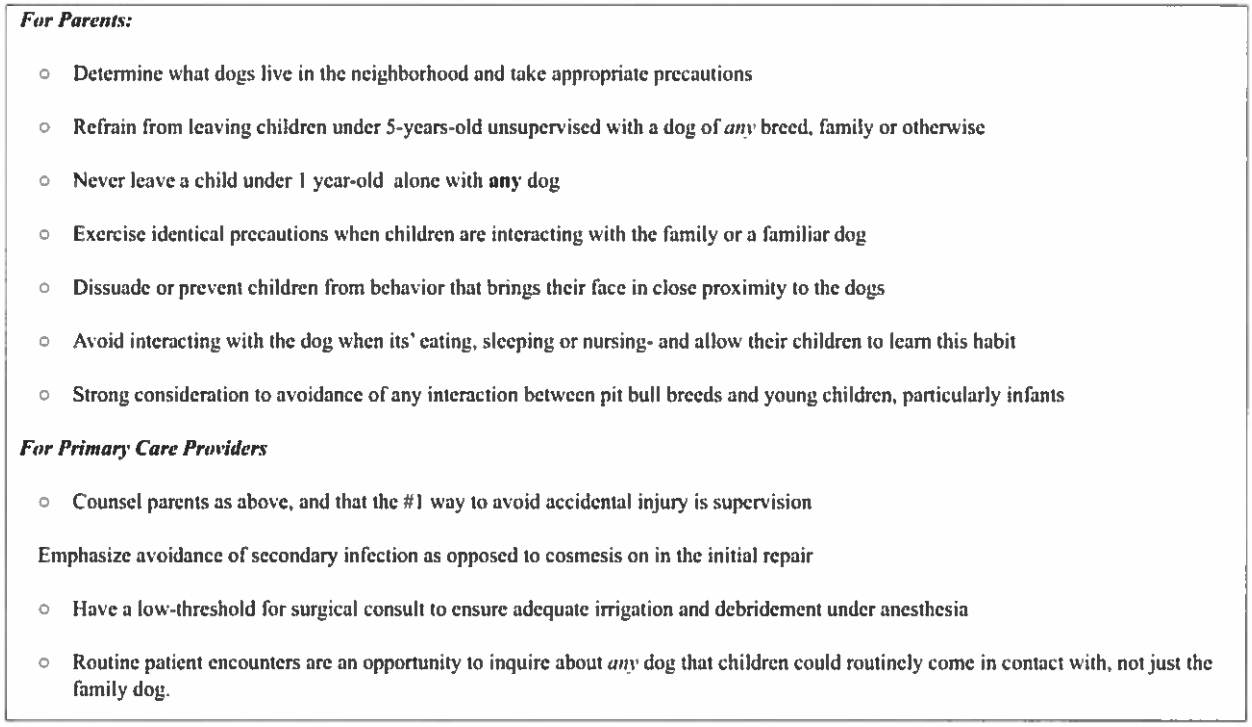

Figure 3. Select recommendations for primary care practitioners and parents based on study findings.

parents about the hazards of handguns, trampolines, or monkey bars.

Though a full discussion of the range of public health interventions is beyond the scope of this report, several comments can be made. There is no shortage of passion or emotion when it comes to the question of banning certain breeds as many owners of the accused dogs staunchly defend their "members of the family." The debate is an active one because, recently, the parents of children attacked by pit bulls petitioned state lawmakers in Georgia for a ban on the breed.[38] In certain locations, as in Canada, breed specific legislation has been shown to decrease the incidence of bites.[39] Consider even that in Aurora, Colorado, where pit bulls have been banned since 2006, a recent study of 537 children found that Labradors were the second most-prevalent biting breed (13.7%), second only to mixed breeds. In other words, a ban of any particular dog alone will not necessarily prevent the severe injuries and mortality, but rather a change in interaction and supervision of children with dogs of any breed. Figure 3 offers some recommendations and is adapted from Reisner et al[19] and American Veterinary Medical Association Task Force on Canine Aggression and Human-Canine Interactions.[40]

Conclusions

This is the first detailed study of dog bite injuries in Georgia and one of the largest studies conducted at a pediatric trauma center. Our study revealed that whereas more than half of all injuries necessitate repair, only approximately 5% require operative intervention. The data also suggest that younger children (<5 years old) than previously reported, and particularly infants, are at high risk for the most severe injuries. The study corroborates the largely negative interactions between pit bulls and children of any age. Parental education and supervision may be the most important measure to prevent severe dog bite injuries.

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Author Contributions

MSG concieved the study idea and developed the research design with JKW.MSG wrote the initial drafts of the manuscript. MSG and BA spear-headed data collection, analysis and along with JKWwrote and edited all portions of the manuscript. JKW provided key insights and changes in discussion and data presentation.

Declaration of Conflicting Interests

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Dog bites of the head and neck: an evaluation of a common pediatric trauma and associated treatment

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ABSTRACT

Purpose: To identify which patients and canines are involved in dog bites of the head and neck, and how they impact health systems.

Materials and methods: This is a single center, retrospective cohort study conducted from January 2012 to June 2013 in an academic, tertiary care center situated between multiple suburban and urban communities. Patients were identified by queried search for all bite-related diagnoses codes.

Results: 334 unique dog bites were identified, of which 101 involved the head and neck. The mean patient age was 15.1 ± 18.1 years. Of the more than 8 different breeds identified, one-third were caused by pit bull terriers and resulted in the highest rate of consultation (94%) and had 5 times the relative rate of surgical intervention. Unlike all other breeds, pit bull terriers were relatively more likely to attack an unknown individual (+31%), and without provocation (+48%). Injuries of the head and neck had an average follow-up of 1.26 ± 2.4 visits, and average specialty follow-up of 3.1 ± 3.5 visits.

Conclusions: The patients most likely to suffer dog bite injuries of the head and neck are children. Although a number of dog breeds were identified, the largest group were pit bull terriers, whose resultant injuries were more severe and resulted from unprovoked, unknown dogs. More severe injuries required a greater number of interventions, a greater number of inpatient physicians, and more outpatient follow-up encounters. Healthcare utilization and costs associated with dog bites warrant further investigation.

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1. Introduction

Animal bites are a preventable public health issue, and yet these injuries have been on the rise. Canine bites became a national concern with the 1985 CDC release that reported as many as 4.7 million Americans are annually bitten by dogs [1]. Of these 4.7 million people, approximately 800,000 dog bite victims seek medical care [1]. At the time of this report, dog bites were not a new issue, this CDC report was one of the first times this type of injury shifted from a local or regional concern to the national stage [2]. Despite this national attention, the rate of dog ownership has continued to increase. In 2001, Shuler and her colleagues estimated that nearly 70 million dogs are owned in the United States, and that over 112 million people, or 40% of the population, have at least one dog in their home [3]. With this increase in ownership, it is now estimated that lifetime risk of being bitten by a dog approaches 50% [4].

Dog bites account for over 80% of mammalian bites [5]. Dog bites, unlike the bites of cats, rats or human are crush injuries [2,6]. At first glance, these injuries can appear less severe than wounds from these other bites because the superficial tissue may remain intact. While the dermis may not be broken, the underlying tissue may still be devitalized by crushing, tearing, and/or avulsing the supporting blood supply [6]. The force applied by a dog's jaw is often estimated to be between 300 and 450 pounds per square inch (PSI) [5,7]. There are reports of some canine bites having forces of upwards of 1800 PSI, but the primary sources for this claim cannot be verified [8–11]. The force generated from some dog bites can fracture bone, dependent on the patient, dog breed and site of bite [12,13].

Dog bites injuries found in the head and neck disproportionately affect children, and have been previously reported to account for 3%-4% of all pediatric emergency visits, and up to 40% of all pediatric traumas [14–18]. These injuries can lead to disfiguring scars and lengthy treatments. The need for facial plastic and reconstructive surgery and scar revisions for these injuries has been previously reported to be as high as 77% for these patients [7]. The treatment of dog bite injuries has been reported as the 5th most common ICD-9 code used by plastic surgeons [19]. Primary closure of open dog bite injuries of the head and neck is an accepted treatment due to the significant morbidity associated with scarring from healing from secondary intention [20–25].

Due to the significant morbidity and controversy surrounding dog bite injuries, this investigation was initiated to identify which patients and canines are involved in these injuries of the head and neck, and how these injuries are currently treated. The objectives of this study include the following: 1) describe the patient population that suffer dog bites in the head and neck, 2) determine the dog breeds and circumstances responsible for these head and neck injuries, and 3) evaluate the current treatment and follow-up care associated with dog bite injuries of the head and neck. We sought to test the following hypotheses: 1) The patients who present with dog bite injuries of the head and neck will be significantly younger, than those bitten in other anatomical locations. 2) The dogs responsible for these injuries will be known to the patient and will be more likely to bite these patients after they are provoked. 3) We further hypothesized that the most severely injured patients would require significantly more resources, measured by consultation, operations, and follow-up.

2. Materials and methods

This is a single center retrospective cohort study conducted using patient data from January 2012 through June 2013. The study was performed at the University of California Davis Health System, a public, academic, tertiary care center, which is situated between multiple suburban and urban communities in Sacramento, California. UC Davis is one of three trauma centers in the greater Sacramento area, and is the sole Level 1 Trauma Center for a catchment area of over two-million people. Prior to the initiation of this study it was approved under the supervision of the UC Davis Institutional Review Board.

Patients in the UC Davis Electronic Medical Record (EMR) were identified by queried search for all bite-related chief complaints and bite-related diagnoses codes (Emergency Department (ED) and/or admit). Patients with non-dog bite injuries were excluded from the study. For each encounter, the following information was extracted from the EMR: date of service, medical record number, name, age, sex, length of stay, chief complaint, diagnosis code, location of incident, insurance provider, and discharge date and time. Further data were extracted from the primary encounter narrative and all subsequent follow-up visits. This extracted data included: time of incident, breed, bodily location of injury, dog's vaccination status, consultations, interventions, inpatient and outpatient antibiotics, relation of dog to patient, circumstances associated with the bite, tetanus and rabies vaccine administration, complications, and follow-up visit encounters. For clarity, the site of injury was dichotomized to general population (GP) of patients where bites affecting the body

Table 1 – Dog Bite Complication Index.

Label	Description	Score
Minor	3 cm or smaller simple laceration Without join involvement Without laceration/breaking of dermis in hand or foot	1
Mild	Greater than 3 cm simple laceration Can involve hands or feet Can involve the face, without neck or eye injury Does not involve poorly vascular structures (joints, cartilage, etc.)	2
Moderate	Greater than 3 cm complex lacerations Requires surgical exploration of wound or surrounding structures Involvement of poorly vascular structures Involvement of neck or eye	3
Severe	Tissue maceration Bone involvement Avulsion and removal of tissue Other destruction of vascular supply	4

(including injuries of the head and neck) and those bites of only the head and neck region (H&N).

The Dog Bite Complication Index (DBCI, Table 1), a scale created prior to this investigation, was developed for the purpose of evaluating dog bites on any anatomic portion of the body. We created the scale for the entire body because, to our knowledge, one had not been previously developed and we intend to use this scale to compare dog bites and treatments in different anatomic locations. The scale was informed by the work of Lackmann et al., who previously developed a scale for categorizing facial dog bit injuries [23]. Lackmann's scale has previously been used by a number of authors to control for injury when comparing various treatments and surgical interventions for injuries of the head and neck [5,7,13,26]. We also incorporated the efforts of Dire et al. and Cummings in order to determine anatomic locations at highest risk for complication following dog bite [27,28].

Statistical analysis was performed using RStudio Version 0.98 (RStudio IDE, Boston, MA). Means are reported with the standard deviation (SD). The data set was evaluated using the Student t-test, Chi-squared, two-tailed population proportionality test, and generalized linear regression. Significance was determined with P values less than 0.05.

3. Results

Excluding insect and human bites, 421 charts returned from the query of the UC Davis EMR. Of those charts, 62 were identified as non-dog bites and 26 were return visits to the ED, thus, yielding a total of 334 unique dog bites. Of these 334 bites, 101 involved the head and neck (Fig. 1). The demographic data for these patients can be found in Table 2. The mean age of the patients with head and neck bites was 15.1 ± 18.1 years (range 11 months to 73 years, median of 6). This value is significantly less than the general dog bite population (t-test, $p < 0.0001$) where the mean age was 28.6 ± 21.5 years (range 11 months to 95 years, median of 26). Of these patients with head and neck bite injuries, 57% of them were below the age of 10, and these bites to the head and neck accounted for 70% of all the dog bite injuries experienced by individuals under the age of 18. The gender distribution was equal in the bites of the head and neck group (male, n = 47, female, n = 53), while the general population of dog bites trended towards men (men, n = 186, women, n = 147) (Test of Equal Proportions, $p < 0.05$).

More than 10 different breeds were identified in the chart. In patients with dog bites to the head and neck, pit bull terriers composed the largest portion of the plurality (32%), with the next most common breed being retrievers (6%). When the population of head and neck dog bites was taken as a whole, there was no relationship between these bites and whether or not they occurred provoked or unprovoked. In the population of patients bitten by pit bulls; however, pit bull terriers were significantly more likely to bite a patient without provocations (χ^2, $p < 0.05$). In the population of head and neck dog bites, the patient was more likely to be bitten by a dog they owned, or knew rather than a strange dog (χ^2, $p < 0.0001$). In the patients bitten by pit bull terriers however, there was no significance difference between known or unknown individuals in terms of bite rate.

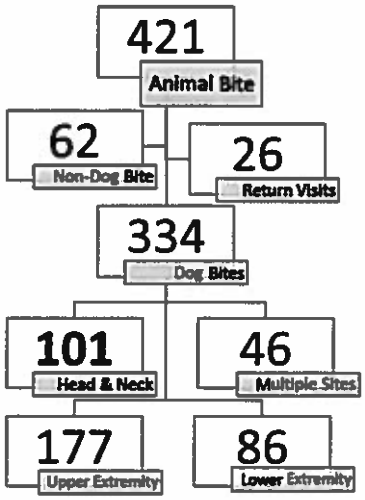

Fig. 1 – Flow chart of enrolled patients. This flow chart graphically displays how select patients were removed for data collection and analysis.

Table 2 – Patient demographic data.[a]

	GP Bites	H&N Bites	P value
N	334	101	
Sex			
Male	47	186	<0.05[c]
Female	53	147	
Age (Years)			
Mean	28.6 ± 18.1	15.1 ± 18.1	< 0.0001[d]
Range	0.92–95	0.92–73	
Median	26	6	
Breed			
Pit Bull	114 (34%)	32 (32%)	
Police Dog[b]	21 (6%)	0 (0%)	
German Shepherd	14 (4%)	5 (5%)	
Chihuahua	10 (3%)	3 (3%)	
Retriever	8 (2%)	6 (6%)	
Boxer	8 (2%)	4 (4%)	
Rottweiler	8 (2%)	3 (3%)	
All Others	28 (8%)	14 (14%)	
Not Reported	123 (37%)	34 (34%)	
Circumstance			
Provoked	84 (25%)	40 (40%)	
Unprovoked	134 (7%)	27 (27%)	
Police Animal[b]	22 (40%)	0 (0%)	
Not Reported	94 (28%)	33 (33%)	
Relationship			
Known	197 (59%)	73 (72%)	
Unknown	87 (26%)	16 (16%)	
Police Dog[b]	28 (8%)	4 (4%)	
Not Reported	22 (7%)	7 (7%)	
DBCI			
Mean	1.83 ± 1.22	2.63 ± 1.04	<0.0001[e]
Median	2.0	3.0	

[a] Results are listed with standard deviation.
[b] Police Dog induced injuries were extracted from reporting because they do not represent normal daily experiences.
[c] Test of Equal proportions.
[d] t-Test.
[e] χ^2 test.

Dog bite treatments were evaluated on the rate of consultation required, intervention required, and antibiotic used. All patients with dog bites were grouped by severity and likelihood of complications using the DBCI. By convention, all injuries that involve the head and neck fell into the mild, moderate, or severe categories. The results of the general dog bite population, and the head and neck bite population can be seen in Table 3. The only significant relationship in Table 3 is found in the general dog bite population between inpatient antibiotics and total number of follow-up visits in the Minor Severity category (Linear Regression Model, $p < 0.005$). The most common complications seen were pain control, infection and wound breakdown. The complication rates for injuries found in the head and neck were similar across intervention type: not requiring closure (6%), repaired in the ED (8%), and repaired in the operative suite (10%). The results failed to reject the null hypothesis that use of antibiotics had an effect on the observed complication rate.

Not included in Table 3 is the subgroup of injuries caused by pit bull terriers. Bites from pit bull terriers were more severe than those of other dogs, with a mean DBCI of 3.2 compared to 2.3 (t-test, $p < 0.0001$). Bites from pit bull terriers had a significantly higher rate of consultation (χ^2, $p < 0.0001$) when compared to other breeds, receiving specialty care in 94% of the cases and in 50% of the cases, respectively. Injuries from pit bull terrier bites were significantly more likely to require surgical repair (χ^2, $p < 0.05$), and had five times the rate of operative repair when compared to other breeds.

Patients with dog bite injuries in the head and neck returned to the medical center for a mean number of 1.26 ± 2.5 follow-up encounters. The percentage of patients returning for follow-up care was commensurate to the injury severity as categorized by the DBCI, increasing progressively from minor (GP 16%; H&N Not Applicable), to mild (GP 31%; H&N 38%), to moderate (GP 48%; H&N 53%), to severe (GP 67%; H&N 70%). As would be expected, the average number of follow-up appointments also followed this progression (Table 3). Not included in Table 3 is the follow-up by practice type. Individuals who sought primary care follow-up returned for a mean of 1.29 ± 0.76 visits. Those who received their follow-up care from the emergency department received 1.57 ± 0.53 follow up encounters. Individuals who followed up with specialty care, defined as otolaryngology–head and neck surgery, facial plastic and reconstructive surgery, plastic surgery, or ophthalmology, returned for an average of 3.11 ± 3.51 encounters. The average severity of the injuries, as measured using the DCBI, was 1.86 ± 0.90, 2.9 ± 0.90, and 3.2 ± 0.69 for primary care, emergency medicine care, and specialty care respectively. When controlling for injury severity, there was not a significant relationship between length of follow-up and encounter specialty (ANOVA, $p = 0.0701$).

4. Discussion

Our first objective was to better characterize the patient population that suffers dog bites of the head and neck due to the paucity of recent studies. In this investigation the patients who were bitten by dogs in the head or neck were more likely to be children under the age of ten, with an equal to slight disposition towards girls than boys. These results agree with previous studies evaluating canine bites at tertiary medical centers [7,13,21,22].

The key finding from our second objective, determining the dogs responsible for bites, is the importance of pit bull terriers in patients with dog bites of the head and neck. The findings of this study are consistent with and extend from previous publications [5,7,11–13,16,21,22,29]. Dog bites from pit bull terriers, compared to bites from all other dogs are more common, more severe, and not related to the dog being provoked. Taken as a whole all other breeds are more likely to bite their owners or other known individuals, either provoked or unprovoked. Pit bull terriers, to the contrary, were found to be more likely to bite a stranger without provocation. Also of note, of the dog bites reported to the Sacramento City Clerk, 204 of the 622 were perpetrated by pit bull terriers [30]. We recognize that the observations of the dog breed and circumstances of dog bites are likely influenced by confounding factors other than just dog breed. Some of these factors may include: 1) treatment or training of dog by owners as protective guard dogs, 2) relative distribution of certain dog

Table 3 – Intervention rate, antibiotics, and follow-up care for dog bites. [a]

	Consultation	No intervention	ED wound closure	Operative closure	Inpatient antibiotics [b]	Outpatient total pills	Outpatient follow-up (number of encounters)
GP Bites							
Minor	18%	92%	5%	0%	0.56 ± 0.71	11.85 ± 11.55	0.44 ± 1.12
Mild	27%	66%	28 %	2%	0.767 ± 0.61	13.79 ± 7.93	0.67 ± 2.32
Moderate	79%	19%	56%	21%	1.19 ± 1.00	15.29 ± 9.76	1.08 ± 1.51
Severe	100%	11%	33%	53%	1.72 ± 1.34	13.0 ± 10.81	2.61 ± 3.67
H&N Bites							
Minor	–	–	–	–	–	–	–
Mild	16%	47%	47%	3%	0.47 ± 0.614	11.06 ± 8.13	0.5 ± 0.75
Moderate	79%	11%	66%	21%	1.11 ± 1.1	14.58 ± 9.56	1.1 ± 1.56
Severe	100%	15%	35%	50%	1.45 ± 1.19	12.85 ± 10.90	3.30 ± 4.53

GP = General Population, patients who presented with bite injuries to all anatomic areas, including head and neck.
H&N = Head and Neck, patients who present with dog bit injuries in the head and neck only.
[a] This table lists standard deviations.
[b] This is a list of the different types of antibiotics. The current data set did not have total number of doses.

breeds in urban, suburban, and rural areas, and 3) the various typical social constructs related to dog ownership.

The third objective of this investigation was to assess the resource used during the treatment of dog bite injuries, with the hypothesis that the most severely injured patients would have a significantly higher requirement for care. With the introduction of the DCBI, this is the first time that the resource utilization of dog bite injuries in the head and neck has been evaluated and compared to the dog bite injuries in other anatomical areas. The results of this investigation show that the more severe injuries did indeed require increased care, as measured by consultation, surgical intervention, and total number of follow-up visits and that this was consistent between anatomic locations.

As expected, the requirement of care gradually rose as the severity of injury increased, but the difference in health care utilization observed between moderate and severe injuries was striking. This observed difference may be due to a fundamental difference between the moderate and severe injury classifications. Intrinsic to the DCBI, severe injuries were characterized by tissue loss (Table 1) which may have required increased follow-up as the injury healed by secondary intention. Regardless of the severity of the presenting injury, we observed that patients who were seen by specialists, tended to have more follow-up encounters than patients who sought care from their primary care physician or emergency physician. While this observation is not statistically significant, the trend speaks to increased system utilization and health care costs. To our knowledge, our preliminary findings on dog bite severity and health system utilization have not been previously studied, and warrant further investigation.

In our evaluation of dog bite follow-up and management patterns, we found that the use of antibiotics did not appear to correlate with either the severity of the injury, or likelihood of complication. The length of treatment was not standardized in any group, and, based upon the literature, the utility of prophylactic antibiotics is unclear [24,31,32]. In the primary analysis of the data there was a strong correlation between the number of follow-up encounters and inpatient antibiotic usage. This relationship appears to be a surrogate for injury severity, as those who had more severe injuries, and increased interventions received more and varied types of antibiotics.

This retrospective chart review has a number of key limitations. Breed, relationship to the offending dog, and circumstances surrounding the presenting injury are self-reported, and as such it is likely that some of the dog breeds have been incorrectly assigned due to either information or recall bias. While these concerns are common to this study design, the impact of these biases on the reported results is unknown. Other limitations of this study include that the datasets we used were not built for research purposes, and at times lack either relevant patient or animal information. In order to mitigate these concerns we not only are expanding to other area health systems, but also have obtained county records for comparison. These records include dog licensure information, and the animal care service records of Sacramento County for the past three years. While none of these data sets are complete, the combination should give an indication of local trends in ownership and breed.

At this time, neither the local, state nor national burden of head neck dog bite injuries is known. The most recent study undertaken to assess the communal burden of this injury type was conducted in 1979, and had significant flaws as detailed in Appendix A. Furthermore, registries of these injuries, such as the Sacramento County Clerk's record of Dog Bites and Animal Registration, are incomplete at best [30]. Although the catchment area for dog bites in this study includes a broad range of socioeconomic and geographic areas, there are likely contextual factors that are unmeasured in this or any retrospective study. Certain areas may contain more of one type of popular dog breeds, which may undergo dog training (protective guard dog) that would affect the geographic distribution of dogs and the dog bites that occur. In future studies, we hope to better control for these confounding variables when evaluating the characteristics of the patients, the attacking dog, and the circumstances of the injury. Overall, this expanded data set will inform efforts to improve dog bite classification, management, and preventive measures.

5. Conclusion

Dog bites are a significant public health concern, and may account for 40% of all pediatric traumas [16]. In this investigation, we found that dog bites of the head and neck disproportionately affected pediatric patients. Among the dog breeds responsible for these head and neck injuries, one-third involved pit bull terriers, whose resulting injuries were more severe, had nearly twice the requirement for specialty consultation, and had higher rate of surgical exploration and repair. Severe injuries required significantly more resources, including specialty consultation, surgical intervention, and follow-up. The impact and costs of dog bites to communities and health systems are relatively unknown. In future investigations we hope to measure the resource utilization in an effort to improve the characterization of the patient-specific and dog related factors that contribute to the dog bites. Ultimately, we intend to improve standardized early treatment and develop preventive measures for these resource intense injuries.

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Author Contributions: Mr. O'Brien and Dr. Tollefson had full access to the data in this study and take full responsibility for the integrity of the data and the accuracy of the data analysis.

- Study concept and design: O'Brien, Andre, Squires, and Robinson.
- Acquisition of data: O'Brien and Andre.
- Analysis and interpretation of data: O'Brien and Andre.
- Drafting of the manuscript: O'Brien and Andre.
- Critical revision of the manuscript: O'Brien, Andre, Squires, Robinson, and Tollefson.
- Statistical analysis and graphic design: O'Brien and Andre.

- Administrative, technical, and material support: O'Brien, Andre, and Tollefson.
- Study supervision: O'Brien, Andre, and Tollefson.

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Previous Presentation: Portions of this data set were presented as posters at the UC Davis Medical Student Research Poster Day, UC Davis, March 6, 2014 and the Association for Clinical and Translational Science Annual Meeting, April 10, 2014. In both instances the posters were not published or made available online.

Additional Contributions: Beth Morris MPH, UC Davis department of Emergency Medicine, retrieved medical records for the study. Brian Andre, Andre & Associates of Orange County, assisted with typesetting and preparation of the figures used in this paper.

Appendix A

One of the unexpected findings in reviewing the available literature is that the true current burden of head and neck dog bites is unknown. In the literature on dog bites of the head and neck, a single study by Karlson is often cited for the burden of this injury [5,11–13,33]. In this investigation, the totality of pediatric head and neck dog bites was reported for the county surrounding Madison, Wisconsin (Dane County). In their analysis they extrapolated their findings, of 133 dog bites per 100,000 children under the age of 10, to the general United States population. At the time of the study, 1979, there were 33 million children under 10 years old, leading to the statistic of 44,000 children who suffer dog bites of the head and neck. A serious flaw of this oftquoted study is the assumption that Dane County is representative of the entirety of the United States.

In the years since this study, the risk of dog bites has been theorized to be related to population density, in addition to poverty status [2–5,34–36]. While the population density is not available for Dane County in 1980, it is possible to calculate the density for Madison, the county's largest and most population dense city. Using the 1980 census data, the urban population density of Madison Wisconsin would have been 78 people per square mile [37,38]. At the same time, nationally, 74% of the country lived in urban areas with a population density of 182 people per square mile. Furthermore, the poverty levels of Dane county and Wisconsin as a state were 9.68 and 7.54, respectively, lower than the nationally reported poverty rate of 12.40 [39]. Since Karlson's investigation, there has not been an assessment of the communal burden of head and neck dog bites. Since 1980, the United States Population has grown by nearly 100 million people and the average population density of urban areas is now 283 people per mile [38]. Due to this gap in knowledge, we are currently developing a collaboration with other Northern California health systems for the purpose of creating a complete data set of these injuries. We hope, with the benefit of this data, to be able to assess the true burden of these injuries and to develop community initiatives directed towards dog bite prevention.

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Mortality, Mauling, and Maiming by Vicious Dogs

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Objective: Maiming and death due to dog bites are uncommon but preventable tragedies. We postulated that patients admitted to a level I trauma center with dog bites would have severe injuries and that the gravest injuries would be those caused by pit bulls.

Design: We reviewed the medical records of patients admitted to our level I trauma center with dog bites during a 15-year period. We determined the demographic characteristics of the patients, their outcomes, and the breed and characteristics of the dogs that caused the injuries.

Results: Our Trauma and Emergency Surgery Services treated 228 patients with dog bite injuries; for 82 of those patients, the breed of dog involved was recorded (29 were injured by pit bulls). Compared with attacks by other breeds of dogs, attacks by pit bulls were associated with a higher median Injury Severity Scale score (4 vs. 1; $P = 0.002$), a higher risk of an admission Glasgow Coma Scale score of 8 or lower (17.2% vs. 0%; $P = 0.006$), higher median hospital charges ($10,500 vs. $7200; $P = 0.003$), and a higher risk of death (10.3% vs. 0%; $P = 0.041$).

Conclusions: Attacks by pit bulls are associated with higher morbidity rates, higher hospital charges, and a higher risk of death than are attacks by other breeds of dogs. Strict regulation of pit bulls may substantially reduce the US mortality rates related to dog bites.

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CASE PRESENTATION

An 11-month-old boy arrived at our level I trauma center after being mauled by 2 pit bulls. The owner of the dogs was the infant's grandmother, who regularly cared for him in her home. Members of the community stated that the dogs were very protective of the owner, especially when outsiders approached the house. The grandmother had gone into the kitchen to get the infant a bottle, leaving him alone in the bedroom. The dogs were unattended in the house. When the grandmother returned to give the infant his bottle, she found the dogs attacking him. She attempted to pull the dogs off the infant, ultimately resorting to stabbing the dogs with a knife. They in turn attacked her. Emergency medical technicians arrived but were unable to rescue the infant from the dogs. Police were called to the scene and shot the dogs.

Upon arrival in the emergency department, the infant was undergoing cardiopulmonary resuscitation, and tracheal intubation had been performed. The infant had suffered multiple bites to the head, torso, and abdomen (Fig. 1). The wounds included a scalp degloving injury and a deep puncture wound to the right subclavian area. In addition, there were multiple bites to the face, neck, chest, buttocks, and genital area. Bilateral chest tubes were placed, and blood products were rapidly infused. Despite maximal efforts, vital signs were not regained, and the infant was declared dead.

INTRODUCTION

Dog bite injuries are a serious public health concern, affecting approximately 1.5% of the US population annually.[1–3] There are nearly 75 million dogs in the United States. The Centers for Disease Control and Prevention estimates that 885,000 people per year require medical attention for dog bites, although some investigators have suggested that the true incidence of dog bites is much higher than that reported (Table 1).[4] In 2006 alone, more than 31,000 patients required reconstructive surgery as the result of dog attacks.[5]

Fatal or near-fatal mauling by dogs is associated with a unique set of breed-specific characteristics that distinguish these attacks from less severe and nonlethal attacks. Historically, before the popularity of pit bulls began to increase, the breed did not account for most deaths related to dog attacks, even though the perbreed fatality rate showed that pit bulls were the leading killer.[6–9] Between 1966 and 1980, for example, although 16 deaths were attributable to German Shepherd Dogs and only 6 were attributable to pit bulls, there were 74,723 registered German Shepherd Dogs and only 929 registered pit bulls (includes American Pit Bull Terrier, the American Staffordshire Terrier, and the Staffordshire Bull Terrier).[6,10] This amounts to 0.2 deaths per 1000 German shepherds but 6.5 deaths per 1000 pit bulls (for a rate 33 times higher). As pit bulls have become more popular and their numbers have increased, so have the numbers of deaths attributable to their attacks. They now are the single breed responsible for the vast majority of deaths due to dog attacks (Table 2). In 2007, 33 fatal cases of dog mauling were reported in 17 states. Texas led the nation with 7 deaths, 6 of which were caused by pit bulls. In 2008 there were 23 fatal dog attacks, and pit bulls were responsible for 65% of these attacks and for all but 1 death due to dog attacks against persons aged more than 3 years.[11,12]

We postulated that patients admitted to a level I trauma center with dog bites would have severe injuries and that the gravest injuries would be those inflicted by pit bulls.

METHODS

This was a retrospective review of cases of dog bites that required the patient to be admitted to our level I trauma center between January 1, 1994, and April 30, 2009. To find our study subjects, we reviewed the hospital's medical records and Trauma Registry. We queried the databases for all patients who were admitted to the Trauma and Emergency Surgery Service during the study period with International Classification of Diseases-9 codes indicating the diagnosis of animal bite by dog. In addition, we obtained information about the breed of attacking dog by reviewing animal injury reports at our city's Animal Care Services department. Patients were excluded from the study if they were not admitted to or treated by the Trauma and Emergency Surgery Service or if they were bitten by animals not considered to be dogs or dog hybrids. We obtained both a waiver of consent and a Health Insurance Portability and Accountability Act waiver of authorization from our university's Institutional Review Board.

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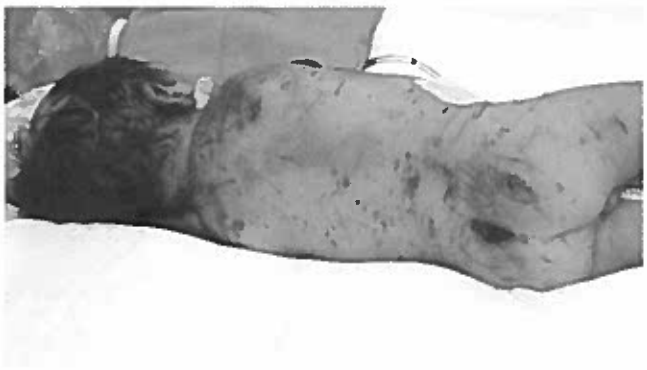

FIGURE 1. Small child fatally injured by 2 pit bulls. Note multiple wounds covering body, with deep wounds to buttock and head. The term *pit bull* refers to dogs from the following breeds: American Pit Bull Terrier, American Staffordshire Terrier, and Staffordshire Bull Terrier.

TABLE 1. National Dog Bite Demographics

Key National Dog Bite Statistics
74.8 million dogs in the United States
1.5% of US population is bitten every year (4.7 million)
885,000 persons per year require medical attention
31,000 persons per year require reconstructive surgery
One of every 5 emergency room visits by children is related to dog bites
33 fatal dog bites in United States in 2007, most (7) in TexasIn contrast, California and New York each reported 1 dog bite fatality in 2007
Median cost per admission for dog bite injuries is $4569 (mean, $7288)
Cost of dog bites to home insurers in 2007 was $356.2 million
Total losses related to dog bites may exceed $1 billion per year

Adapted from References (Sacks, Kresnow et al. 1996;[7] Voelker 1997;[1] Weiss, Friedman et al. 1998;[2] CDC 2001;[5] CDC 2003; www.dogsbite.org <http://www.dogsbite.org>. Dogsbite.org anuary 3, 2009; www.dogsbite.org <http://www.dogsbite.org>. <http://www.youtube.com/watch?v = X8nVTctxUDE> October 25, 2008).

We collected information about the demographic characteristics of dog bite victims, their outcome, and their clinical course by reviewing hospital medical records, photographs, and radiographic results. In addition, we gathered information about the type and location of wounds and the severity of injury. We also determined, when possible, the characteristics of the attacking dog: breed; socialization information; attack provoked or unprovoked; whether dog was known to victim; location of attack; restraint applied to dog, if any; number of dogs involved in the attack; sex and sexual characteristics (neutered/spayed); rabies vaccination status; and whether dog was a trained attack, guard, or working dog. Finally, we reviewed hospital charges to assess the financial costs of these injuries.

We assigned all pit bulls breeds and pit bull hybrids to a category named *pit bull*, and we assigned dogs of other breeds to a category named *other breeds*. We used these breed categories to compare the characteristics of the victims, the characteristics of the attack, and the characteristics of the attacking dog. We summarized binary outcomes as counts and percents, and we summarized continuously distributed outcomes as mean and SD or median and range, as appropriate. We assessed the statistical significance of any differences associated with breed categories by using the Pearson chi-square test or the Fisher exact test for binary outcomes or by using analysis of variance or the Kruskal-Wallis test, as appropriate, for continuously distributed outcomes. All statistical testing was 2-sided, and significance was assigned at the level of $P = 0.05$. SAS Version 9.1.3 for Windows (SAS Institute, Cary, NC) was used for all analyses.

TABLE 2. Breed of Dog Associated With Involvement in Fatal Attacks, 2007 National Registration Data From the American Kennel Club, and Relative Risk of Fatal Attack*

Breed†	Number of Dogs Involved in Fatal Attacks	Number of Dogs Registered AKC	Relative Risk of Fatal Attack Per Dog§
Pit Bull‡	113	2239	2520
Neapolitan Mastiff	2	357	280
Chow Chow	2	1567	65
Rottweiler	18	14,211	65
Great Pyrenees	2	1916	50
Parson Russell Terrier	1	1096	45
Old English Sheepdog	1	1206	40
Siberian Husky	6	9048	35
Bullmastiff	1	3735	15
Doberman Pinscher	2	11,381	10
Australian Shepherd or Mix	1	6471	10
Mastiff Mix	1	7160	5
German Shepherd Dog	4	43,376	5
Boxer	1	33,548	1.5
Golden Retriever or Mix	1	39,659	1.5
Labrador Retriever or Mix[2]	2	114,110	1
Total	158		

Abbreviation: AKC, American Kennel Club.

*Adapted from reference 14.

†Data presented only for dog breeds for which registration information is available from the American Kennel Club (AKC). The AKC does not register the Perro de Presa Canario, Wolf Hybrids, or dogs of unknown mixed breed.

‡The term *pit bull* refers to dogs from the following breeds: American Pit Bull Terrier, American Staffordshire Terrier, and Staffordshire Bull Terrier.

§Data for Labrador Retrievers and Labrador Mix are combined. Relative Risk is normalized to Labrador Retriever and Labrador Mix.

RESULTS

During the 15-year period reviewed in this study, 228 dog bite injuries were treated by our Trauma and Emergency Surgery Service. Of the 228 attacks reviewed, the breed of dog was reported for 82 attacks. Of those 82 attacks, 29 (35%) were attributed to pit bulls and 53 (65%) were attributed to all other breeds of dogs combined.

Characteristics of the Victims

The mean age of the 228 victims of dog attacks was 21 years. Of persons attacked by dogs of known breed, those mauled by pit bulls ranged in age from 11months to 90 years (mean, 28 years), whereas those attacked by dogs of all other breeds ranged in age from newborn to 69 years (mean, 16 years). The percentage of victims aged 18 years or older was higher for those attacked by pit bulls (51.7%) than for those attacked by other breeds (26.4%), but the age distributions did not vary significantly according to the breed category (Table 4; $P = 0.096$). Additionally, there was no significant difference between the sex of victims attacked by pit bulls (male victims, 44.8%) and the sex of victims attacked by other breeds (male victims, 60.4%; $P = 0.176$). Vital signs upon admission were similar for victims attacked by pit bulls and those attacked by other breeds (systolic blood pressure, $P = 0.285$; heart rate, $P = 0.208$; respiratory rate, $P = 0.123$) (Table 4). The median Injury Severity Scale (ISS) score for

victims mauled by pit bulls (ISS, 4) was significantly higher than that for victims attacked by other breeds (ISS, 1; $P = 0.002$); however, the Abbreviated Injury Scale category did not vary significantly according to breed, nor did the Trauma and Injury Severity Scores ($P = 0.412$). The percentage of victims with an admission Glasgow Coma Scale (GCS) score of 8 or lower was significantly higher for victims attacked by pit bulls (17.2%) than for victims of attacked by other breeds (0%; $P = 0.006$). Approximately one-third of all victims underwent surgical procedures for wound repair; this proportion was similar across breed categories (data not shown). During the first 30 days after the attack, the number of hospital-free days was significantly lower for victims attacked by pit bulls (median, 28 days; range, 0–29 days) than for victims attacked by other breeds (median, 28 days; range, 21–29 days; $P = 0.009$). During the same period, the number of intensive care unit (ICU)-free days was significantly lower for victims attacked by pit bulls (median, 30 days; range, 0–30 days) than for those attacked by other breeds (median, 30 days; range, 23–30 days; $P = 0.027$). Median hospital charges (victims attacked by pit bulls, $10,500 [range, $2500–$42,700]; victims attacked by other breeds, $7200 [range, $1000–$32,400]) $P = 0.003$; and the risk of death (victims attacked by pit bulls, 10.3%; victims attacked by other breeds: 0%; $P = 0.041$) were significantly higher for victims of pit bull attacks.

Our review of records found 3 cases in which fatalities resulted from dog attacks. One of these cases was detailed above; a description of the other 2 cases follows.

A 10-year-old girl was attacked by a neighbor's pit bull, which was usually chained in the neighbor's yard. Tracheal intubation was performed at the scene, and cardiopulmonary resuscitation was in progress when the child arrived at the hospital. No vital signs or signs of life were detectable. Postmortem examination showed a deep laceration to the anterior left base of neck; this wound was believed to be the cause of death.

The third case was that of a 90-year-old man attacked by his own 2 pit bulls just after midnight. He was alone when injured and was found by emergency medical services personnel lying on the living room floor of his home, moaning but unresponsive. When the patient arrived at the hospital, tracheal intubation was performed, and he was taken to the operating room for debridement of wounds, which included multiple deep lacerations to his upper extremities, puncture wounds to his torso and lower extremities, and testicle avulsion. The patient spent 5 days in the ICU because of cardiac complications and ultimately died.

Characteristics of the Attack and the Dog

We evaluated the relationship between the victim and dog (Table 5); this information was available for 58 of the 228 attacks. Dogs were classified as belonging to an acquaintance (5.2%), the victim's family (44.8%), a neighbor (20.7%), a relative (17.2%), or someone unknown to the victim (12.1%). There was no association between the breed of the attacking dog and the victim's relationship to the dog ($P = 0.868$), the location of the attack ($P = 0.725$), the type of restraint, if any, used on the dog ($P = 0.133$), the type of provocation, if any ($P = 0.182$), the sex of the dog ($P = 0.565$), or the rabies vaccination status of the dog ($P = 0.201$). The mean (±SD) number of dogs involved in the attack was higher when pit bulls were involved (1.3 ± 0.7 dogs) than when other breeds were involved (1.0 ± 0.2 dogs), but the difference was not statistically significant ($P = 0.075$).

DISCUSSION

The main findings of this study are that, in comparison to victims attacked by other breeds of dogs, victims attacked by pit bulls have a higher ISS score, a higher risk of an admission GCS score of 8 or lower, fewer hospital-free and ICU-free days, higher hospital charges, and a higher risk of death.

TABLE 3. Characteristics of Pit Bulls

Fatal Pit Bull Attacks Nationally
Pit bulls attack indiscriminately
Responsible for 65% of all fatal attacks in 2008
6 of 7 fatal dog bites in Texas in 2007 were inflicted by pit bulls
94% of attacks on children by pit bulls were unprovoked
81% of attacks that occurred off the owner's property involved pit bulls
One person is killed by a pit bull every 14 days
One body part is severed and lost every 5.4 days as a result of pit bull attacks
2 persons are injured by pit bulls every day
1.5 pit bulls are shot to death every day

Adapted from references (Sacks, Kresnow et al. 1996;[7] CDC 2001;[5] CDC 2003; www.dogsbite.org<http://www.dogsbite.org>. Dogsbite.org anuary 3, 2009.; www.dogsbite.org<http://www.dogsbite.org>.<http://www.youtube.com/watch?v=X8nVTctxUDE > October 25, 2008).

The term *pit bull* refers to dogs from the following breeds: American Pit Bull Terrier, American Staffordshire Terrier, and Staffordshire Bull Terrier.

Characteristics of the Pit Bull Breed

The pit bull is unique in many ways. Historically, the breed was derived from the "butcher's dog" developed for the blood sport of bull-baiting in England. The dogs were intentionally bred to be stronger than other dogs and to engage in dangerous behaviors that would favor their winning in the ring by fighting a bull to the death. When this sport was banned in England in approximately 1835, the owners took their dogs to the coal mining communities of Staffordshire County. There, the dogs were placed into coal pits to fight one another, and the breed was manipulated to be quicker and more agile. This breeding eventually resulted in the smaller, tenacious terriers now known as the American Pit Bull Terrier, the American Staffordshire Terrier, and the Staffordshire Bull Terrier. The name "pit bull" is associated with dogs displaying these phenotypes.[13,14] These fighting dogs were bred and trained *not* to display behavioral signals of their intentions so that they would have an advantage in the ring. For this reason, pit bulls are frequently known to attack "without warning."[10] For example, 1 study found that 94% of attacks on children by pit bulls but only 43% of attacks on children by other breeds of dogs were unprovoked.[15] Mythically, these dogs have been ascribed with supernormal strength and bite force and with "locking jaws," which are claimed to be responsible for the devastating injuries that the dogs can produce. Although it is clear that this breed of dog is muscular, strong, and tenacious, there is no evidence for the extreme bite force often reported in the applicable literature. The results of osteological studies of skull and jaw morphology suggest that, as the mass of the dog increases, small differences in mechanics due to skull morphology may produce a theoretical bite force advantage.[16] Dr. Brady Barr of the National Geographic Society tested the bite strength of live animals. The bite force of the Rottweiler was 328 psi, that of the German Shepherd Dog was 238 psi, and that of the pit bull was 235 psi. In comparison, the bite force of a gray wolf is more than 400 psi whereas that of a lion is 600 psi.[17] Therefore, it is not the biting force of pit bulls that is responsible for the damage they inflict. With regard to the locking-jaw theory, although pit bulls are bred to not let go, there is no such thing as a locking jaw mechanism in pit bulls or in any other canine.[13]

The attack pattern of pit bulls is different from that of other dogs. With other dogs, children are usually at highest risk of being

TABLE 4. Characteristics of 228 Dog Bite Victims Treated at a Level I Trauma Center Between January 1, 1994, and April 30, 2009

Characteristic	Breed of Attacking Dog			All Dogs, n	*P* Value†
	Pit Bull*, n	Other Breeds, n	Total, Breed Known, n		
Dog attacks, n	29	53	82	228	
Patient age, n (%)					0.096‡
≤6 years	8 (27.6)	22 (41.5)	30 (36.6)	82 (36.0)	
6–11 years	6 (20.7)	13 (24.5)	19 (23.2)	42 (18.4)	
12–17 years	0 (0)	4 (7.5)	4 (4.9)	9 (3.9)	
≥18 years	15 (51.7)	14 (26.4)	29 (35.4)	95 (41.7)	
Dog attacks, n	29	53	82	228	
Patient sex, n (%)					0.176§
Male	13 (44.8)	32 (60.4)	45 (54.9)	131 (57.5)	
Dog attacks, n	29	49	78	201	
Systolic BP, mean (SD)	117.1 (35.9)	124.3 (23.2)	121.6 (28.6)	125.5 (25)	0.285¶
Dog attacks, n	29	50	79	207	
Heart rate, mean (SD)	102.4 (42.3)	112.4 (27.5)	108.8 (33.8)	105 (31)	0.208¶
Dog attacks, n	29	49	78	201	
Respiration rate, mean (SD)	19 (7.7)	21.2 (4.7)	20.4 (6)	20.4 (5.4)	0.123¶
Dog attacks, n	29	53	82	228	
ISS					
Median (IQR)	4 (4)	1 (0)	1 (3)	1 (3)	0.002**
Minimum, maximum	1, 24	0, 25	0, 25	0, 30	
AIS-Head and Neck ≥ 3, n (%)	2 (7.6)	2 (3.8)	4 (5.1)	11 (5.1)	0.77§
AIS-Face ≥ 3, n (%)	0 (0)	2 (3.8)	2 (2.5)	2 (0.9)	0.17§
AIS-Chest ≥ 2, n (%)	1 (3.8)	0 (0)	1 (1.3)	3 (1.4)	0.27§
AIS-Abdomen n (%) or AIS-Pelvis ≥ 3	1 (3.8)	0 (0)	1 (1.3)	3 (1.4)	0.44§
AIS-Extremity ≥ 3, n (%)	1 (3.8)	0 (0)	1 (1.3)	8 (3.6)	0.25§
AIS-External ≥ 2, n (%)	2 (7.7)	2 (3.8)	4 (5.1)	7 (3.2)	0.06§
Dog attacks, n	29	53	82	228	
TRISS, Mean (SD)	0.92 (0.23)	0.86 (0.34)	0.88 (0.30)	0.81 (0.38)	0.412¶
Dog attacks, n	29	49	78	208	
GCS Score ≤ 8, n (%)	5 (17.2)	0 (0)	5 (6.4)	10 (4.8)	0.006‡
Dog attacks, n	28	53	81	227	
Hospital-free days Mean (SD)	22.5 (10.9)	28 (1.5)	26.1 (6.9)	26 (6.5)	0.009**
Median	28	28	28	28	
Range	0, 29	21, 29	0, 29	0, 30	
Dog attacks, n	29	53	82	228	0.027**
ICU-free days					
Mean (SD)	25.5 (10.3)	29.7 (1.2)	28.2 (6.5)	28.9 (4.7)	
Median	30	30	30	30	
Range	0, 30	23, 30	0, 30	0, 30	
Dog attacks, n	29	51	80	214	0.003**
Hospital charges (K$)					
Mean (SD)	32.2 (78.9)	8.0 (6.8)	16.8 (48.7)	14.9 (45.0)	
Median	10.5	7.2	8.1	6.5	
Range	2.5, 42.7	1.0, 32.4	1.0, 42.7	1.0, 45.2	
Dog attacks, n	29	53	82	228	
Mortality, n (%)	3 (10.3)	0 (0)	3 (3.7)	3 (1.3)	0.041‡

Abbreviations: AIS, Abbreviated Injury Scale score; BP, blood pressure; GCS, Glasgow Coma Scale score; ICU, intensive care unit; IQR, interquartile range; ISS, Injury Severity Scale score; K$, thousands of dollars; SD, standard deviation; TRISS, Trauma and Injury Severity Score.

*The term *pit bull* refers to dogs from the following breeds: American Pit Bull Terrier, American Staffordshire Terrier, and Staffordshire Bull Terrier.

†Comparison of data in the columns labeled "Pit Bull" and "Other Breeds."

‡Statistical significance determined by Fisher exact test.

§Statistical significance determined by Pearson chi-square test.

¶Statistical significance determined by analysis of variance (ANOVA).

**Statistical significance determined by Kruskal-Wallis test.

TABLE 5. Characteristics of the Attack and the Dog Involved

Characteristic	Breed of Attacking Dog			All Dogs, n	*P* Value†
	Pit Bull*, n	Other Breeds, n	Total, Breed Known, n		
Dog attacks, n	19	23	42	58	
Relationship of victim to dog, n (%)					0.868‡
Acquaintance's dog	1 (5.3)	1 (4.3)	2 (4.8)	3 (5.2)	
Family dog	9 (47.4)	11 (47.8)	20 (47.6)	26 (44.8)	
Neighbor's dog	5 (26.3)	4 (17.4)	9 (21.4)	12 (20.7)	
Relative's dog	2 (10.5)	5 (21.7)	7 (16.7)	10 (17.2)	
Dog unknown to victim	2 (10.5)	2 (8.7)	4 (9.5)	7 (12.1)	
Dog attacks, n	15	18	33	42	
Attack Location, n (%)					0.725‡
In house	3 (20)	6 (33.3)	9 (27.3)	12 (28.6)	
In yard	9 (60)	9 (50)	18 (54.5)	22 (52.4)	
Dog attacks, n	11	14	25	34	
Dog restraint, n (%)					0.133§
Unrestrained	7 (63.6)	13 (92.9)	20 (80)	28 (82.4)	
Dog attacks, n	21	29	50	71	
Provocation, n (%)					0.182‡
Running	0 (0)	1 (3.4)	1 (2)	1 (1.4)	
Feeding	0 (0)	1 (3.4)	1 (2)	1 (1.4)	
None	1 (4.8)	6 (20.7)	7 (14)	13 (18.3)	
Playing	2 (9.5)	4 (13.8)	6 (12)	8 (11.3)	
Petting	2 (9.5)	0 (0)	2 (4)	4 (5.6)	
Pulling	0 (0)	1 (3.4)	1 (2)	1 (1.4)	
Dog attacks, n	21	23	44	59	
Number of dogs involved in attack, mean (SD)	1.3 (0.7)	1 (0.2)	1.2 (0.5)	1.2 (0.5)	0.075**
Dog attacks, n	7	26	33	33	
Sex of Dog, n (%)					0.565‡
Male	5 (71.4)	20 (76.9)	25 (75.8)	25 (75.8)	
Dog attacks, n	4	7	11	19	
Rabies vaccination, n (%)					0.201¶
Yes	2 (50)	6 (85.7)	8 (72.7)	15 (78.9)	

*The term *pit bull* refers to dogs from the following breeds: American Pit Bull Terrier, American Staffordshire Terrier, and Staffordshire Bull Terrier.
†Comparison of data in the columns labeled "Pit Bull" and "Other Breeds."
‡Statistical significance determined by Fisher exact test.
§Statistical significance determined by analysis of variance (ANOVA).
¶Statistical significance determined by Pearson chi-square test.
**Kruskal-Wallis Test.

bitten. In contrast, pit bulls seem to attack adults almost as frequently as they attack children.[18] Pit bulls not only are notorious for their indiscriminate attack pattern but also are well known for the tenacity with which they continue with an attack. The case fatality reported above involved an infant that was mauled by 2 pit bulls. These dogs had previously bitten an 8-year-old relative in the face. When the dog's owner attempted to stop the attack on the infant by stabbing the dogs with a knife, she became a victim herself, and police officers had to shoot (kill) the dogs at the scene.[19] It is not uncommon to hear of witnessed attacks in which the pit bulls could not be stopped from attacking.[20,21]

The inbred tenacity of pit bulls, the unrelenting manner in which they initiate and continue their attacks, and the damage they cause are the result of both genetics and environment. Therefore, this breed of dog is inherently dangerous.[10,13,16,17,22] As stated by 1 author, "Temperament is not the issue, nor is it even relevant. What is relevant is actuarial risk. If almost any other dog has a bad moment, someone may get bitten, but will not be maimed for life or killed, and the actuarial risk is accordingly reasonable. If a Pit Bull Terrier or a Rottweiler has a bad moment, often someone is maimed or killed, and that has now created off-the-chart actuarial risk, for which the dogs and their victims are paying the price."[18]

Over a recent 3-year period from January 2006 to March 30, 2009, a total of 98 dog bite fatalities involving 179 dogs occurred; 60% of the deaths were caused by pit bulls, and 76% were caused by pit bulls and Rottweilers.[11] A total of 113 pit bulls were involved in these deaths, and they accounted for 63% of the dogs involved in fatal attacks (Table 2). If the risk of fatal attack is normalized to Labrador Retrievers and Labrador-mix breeds (the most common registered dog in the United States), the relative risk of death related to pit bull attacks is more than 2500 times higher. Data show that, in 2008, pit bulls alone were responsible for 81% of attacks that occurred off the owner's property; of these attacks, 85% involved more than 1 dog.11 Although adults aged 21 to 54 years composed only 19% of all victims who died, 82% of these deaths were caused by pit bull attacks. Over a 3-year period, 54% of deaths due to pit

bull attacks occurred among adults (aged 21 years or older) and 46% occurred among children (aged 11 years or younger). In one 85-day period from July to September 2008, pit bulls were involved in 127 dog attacks, 57% of which occurred off the owner's property. In these attacks, 158 people were injured, 63% of them severely; 10% of the victims suffered severed body parts; and 6 victims were killed.[12] In the same period, 128 dangerous pit bulls had to be shot to death by police officers or citizens.[12] A closer look at these figures indicates that 1 person is killed by a pit bull every 14 days, a person loses a body part to a pit bull attack every 5.4 days, 2 persons are injured by pit bulls each day, and 1.5 pit bulls are shot to death each day (Table 3).

Children as Frequent Targets of Dog Attacks

A 2008 national survey found that there is a general lack of knowledge regarding dog behavior and safety practices for dog-child interactions.[22–24] This finding partially explains the fact that children are 3 times as likely as adults to require medical attention for dog bites and the fact that injury rates seem to be highest among children aged 5 to 9 years.[25–30] Children are more likely to engage in behaviors that unknowingly provoke dogs.[15] Children are also more likely to be bitten in the head, neck, and face; thus, the number of children requiring medical attention is higher than the number of adults who require such care.[5,27,31–37] Children not only suffer physical scars but also sustain substantial and lasting psychological effects. Posttraumatic stress disorder is more common among children involved in violent attacks than among those experiencing only minor or incidental bites by a pet.[38]

Costs of Dog Bites

Dog bites are the second most costly public health problem in the United States. In Kansas City, Missouri, between 1998 and 2002 the median cost per visit to an emergency department for a dog bite was $300, and the median cost per admission to a hospital was $4698.[37] A recent single-center review of 1347 nonfatal dog bites experienced by children reported that the direct cost of medical care during the 8-year study period was $2.15 million; of this, $1.4 million was covered by Medicaid and another $122,000 was considered "self pay," which is often written off as charity care.[36] This amounted to a cost of $1596 per incident, including the cost of care for the 91% of patients treated in the emergency department and released.[36] In Pennsylvania in 1995, the charges for hospitalizations that resulted from 469 dog bites totaled $3.4 million; the median charge was $4569 (mean charge, $7288).[39] Notably, government payment sources were responsible for 48% of the total costs.[39] Insurance estimates from 2007 placed the annual cost of dog bites for home insurers in the United States at $356.2 million; total losses may exceed $1 billion per year.[40]

Dog bite ordinances vary widely across the United States. Seventeen states have "one bite" laws that do not hold the dog owner accountable for the actions of a dangerous dog until after the dog has caused harm, at which point it can be considered potentially dangerous or vicious. Twelve states have laws that specifically forbid municipalities to enact breed-specific laws or ordinances.[41,42] Currently, 250 cities in the United States have breed-specific ordinances, even though some of these cities are in states that prohibit breed-specific laws. Texas, the state that leads the nation in dog bite fatalities, is a "one bite" state that prohibits breed-specific laws.

In Texas, the laws regarding dogs that have been deemed dangerous are quite strict; these laws are similar to those regarding dangerous wild animals. The dangerous-dog law in Texas requires special registration and containment of the animal and imposes strict insurance liability requirements on owners. Similar requirements exist with regard to the ownership of dangerous wild animals, such as lions, tigers, and bears. The difference between the approach to wild animals and the approach to dogs is that wild animals are defined as dangerous on the basis of their species, whereas dogs must cause bodily injury before they can be determined to be dangerous. Texas law specifically prohibits municipalities from enacting legislation specific to dog breeds; although municipalities can ban or restrict the ownership of species of wild animals within their jurisdiction, they cannot regulate the ownership of specific breeds of dogs.[43,44]

Our study showed that the dog bite injuries experienced by patients admitted to our level I trauma center over a 15-year period were severe, as manifested by the fact that nearly one-third of patients required operative intervention. Of particular interest was the fact that pit bulls, which were found to have attacked older persons, and inflicted much more devastating injuries than other breeds of dogs (as indicated by higher median ISSs and a higher percentage of victims with a GCS score ≤ 8), injuries that in some cases led to death. In addition, patients attacked by pit bulls experienced more morbidity (as indicated by higher ISSs and fewer hospital-free and ICU-free days) and incurred higher hospital charges than those attacked by other breeds. We should state that our study is limited by its retrospective nature and the limited number of cases in which the breed of dog responsible for the attack could be determined. This lack of information may compromise the validity of our results implicating the pit bull as a major culprit in severe dog bites admitted to our trauma center.

CONCLUSIONS

Dog bites are a serious public health concern in the United States and across the world. They result in substantial emotional and physical trauma and in a substantial economic cost to the victims and to society. Fortunately, fatal dog attacks are rare, but there seems to be a distinct relationship between the severity and lethality of an attack and the breed of dog responsible. The unacceptable actuarial risk associated with certain breeds of dogs (specifically, pit bulls) must be addressed. These breeds should be regulated in the same way in which other dangerous species, such as leopards, are regulated. Individual municipalities need the power to enact ordinances that can protect their citizens from this risk. If they are to obtain such power, the issue must be addressed at the local, county, and state legislative levels.

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